Name: Taylor Larrechea

$x_c = \frac{1}{\omega c}$

Electronics for Scientists

RC Highpass Filter

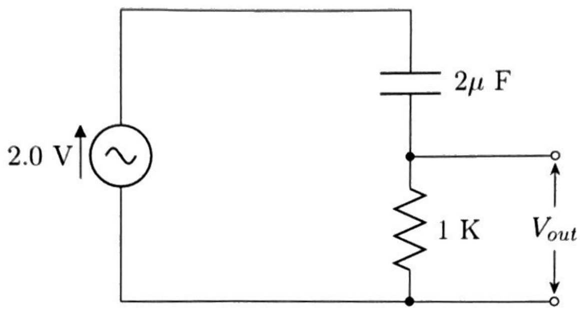
4/4

Instructions

Complete the following exercises to the best of your ability.

1. Determine the reactance of a capacitor with a capacitance equal to 0.5 μF at frequencies of 10 Hz, 100 kHz, and 10 MHz.

2. The circuit shown below has a 2.0 V AC signal in series with a 0.5 μF capacitor and a 1 K resistor. Treat the circuit as a voltage divider to find the output voltage at frequencies 10 Hz, 1 kHz, 100 kHz, and 10 MHz.



$\omega = 2\pi f$

$x_c = \frac{1}{\omega c}$

3. The above circuit is a highpass filter. What is its 3 dB frequency?

1. $f = 10$ Hz : $x_c = \frac{1}{2\pi(10Hz)(0.5\times10^{-6}F)} = \boxed{31{,}831\,\Omega}$ $\quad \boxed{x_{10} = 31{,}831\,\Omega}$

$f = 100$ kHz : $x_c = \frac{1}{2\pi(100kHz)(0.5\times10^{-6}F)} = \boxed{3.1831\,\Omega}$ $\quad \boxed{x_{100} = 3.18\,\Omega}$

$f = 10$ MHz : $x_c = \frac{1}{2\pi(10MHz)(0.5\times10^{-6}F)} = \boxed{0.031831\,\Omega}$ $\quad \boxed{x_{10} = 0.0318\,\Omega}$

$V_{out} = \left(\frac{\omega RC}{1+\omega RC}\right) V_{in}$

$V_0 = \left(\frac{2\pi f RC}{\sqrt{1+(2\pi f RC)^2}}\right) V_{in}$

$f_{3dB} = \frac{1}{2\pi RC}$

2. V_{out} :

R = 1KΩ
C = 2μF
Vin = 2V

$f = 10$ Hz : $V_0 = \left(\frac{2\pi(10Hz)\cdot RC}{\sqrt{1+(2\pi\cdot 10Hz\cdot RC)^2}}\right) V_{in} = \boxed{0.249\,V}$ $\quad$ 0.06V $\quad \boxed{V_{10Hz} = 0.249\,V}$

$f = 1$ KHz : $V_0 = \left(\frac{2\pi(1KHz)\cdot RC}{\sqrt{1+(2\pi\cdot 1KHz\cdot RC)^2}}\right) V_{in} = \boxed{1.99\,V}$ $\quad$ 1.5V $\quad \boxed{V_{1KHz} = 1.99\,V}$

$f = 100$ kHz : $V_0 = \left(\frac{2\pi(100kHz)\cdot RC}{\sqrt{1+(2\pi\cdot 100kHz\cdot RC)^2}}\right) V_{in} = \boxed{2\,V}$ $\quad \boxed{V_{100kHz} = 2\,V}$

$f = 10$ MHz : $V_0 = \left(\frac{2\pi(10MHz)\cdot RC}{\sqrt{1+(2\pi\cdot 10MHz\cdot RC)^2}}\right) V_{in} = \boxed{2\,V}$ $\quad \boxed{V_{10MHz} = 2\,V}$

3. $f_{3dB} = \frac{1}{2\pi RC} = \frac{1}{2\pi(1K\Omega)(2\mu F)} = 79.5$ Hz

R = 1KΩ
C = 2μF

$f_{3dB} = 79.5$ Hz

Taylor Lavrachen
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HW 4

$\boxed{1.33}$ RC low pass attenuate to 6 dB ?
Phase shift ?

a.) $v_1 = \frac{1}{2} v_0$

$dB = 20\log_{10}\left(\frac{v_1}{v_0}\right)$
$= 20\log_{10}\left(\frac{1}{2}\right)$
$dB = -6.02\ dB$

$\frac{v_1}{v_0} = \frac{1}{2}$

$\frac{v_0}{v_1} = (1 + \omega^2 R^2 C^2)^{1/2}$

$\left(\frac{v_0}{v_1}\right)^2 = 1 + \omega^2 R^2 C^2$

$4 - 1 = \omega^2 R^2 C^2$

$\frac{3}{R^2C^2} = \omega^2$

$\frac{\sqrt{3}}{RC} = \omega$

$f = \frac{1}{\omega RC} = \frac{1}{\sqrt{3}\cdot\frac{RC}{RC}} = \frac{1}{\sqrt{3}} = 0.57\ Hz$

$f = 0.57\ Hz$

b.) The phase shift of this would be ~~60°~~.